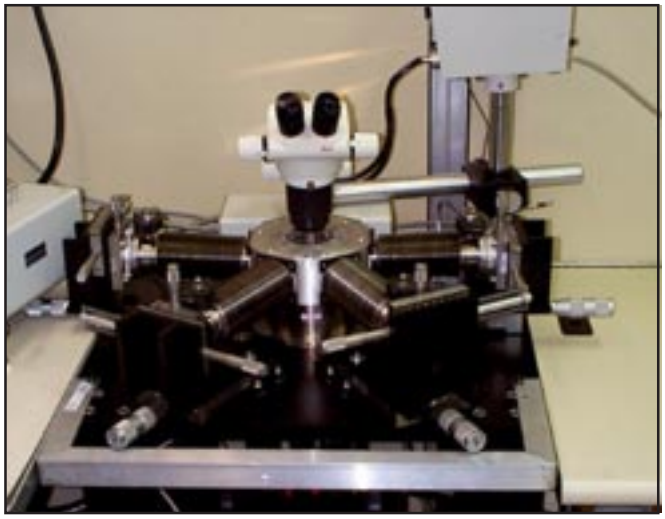
Cryogenic Microwave Power Measurements



Payoff

The capability to predict a transistor's DC and microwave behavior in a space environment is essential to developing successful space devices for the Air Force. With the advanced capabilities of the on-wafer cryogenic microwave load pull system, other technology areas will benefit from lower cost, more reliable device technologies. The information obtained using this new evaluation tool (temperature-dependent transistor characteristics, reduced breakdown voltage, carrier freeze-out and carrier trapping issues) can also be applied to the advancement of ground-based radar systems (a possible cryogenic ground-based radar). Other uses include battlefield wireless communications for military personnel and unmanned air vehicle technology both requiring compact transmitters without elaborate cooling systems, as well as, commercial cellular phone base operations and some air traffic control radar systems.

Accomplishment

The Air Force Research Laboratory's (AFRL's) Sensors Directorate (SN) personnel worked with Dr. James Hwang of Lehigh University, Bethlehem, PA, to develop a unique Department of Defense (DoD) capability to evaluate the reliability of next generation power transistors through on-wafer microwave load pull of power devices at cryogenic temperatures down to 80K. Scientists have successfully performed on-wafer microwave temperature-dependent cryogenic power measurements, as well as DC cryogenic measurements, on wide-bandgap GaN/AlGaN High Electron Mobility Transistor (HEMT) dies using this technically advanced cryogenic microwave measurement system. This system will be key in developing low-cost, versatile device technologies for Air Force space applications.

Background

Transistors made of wide-bandgap semiconductors can operate under high-voltage and high-temperature conditions. However, less microwave data is available about wide-bandwidth and low-temperature operations of these research transistors. As space technologies become the Air Force's focus, it is increasingly more important to know how next-generation power devices, such as wide-bandgap transistors, will react to the drastic environmental changes found in space. In response to this technology need, a cryogenic microwave power measurement system has been successfully developed and demonstrated to identify reliability problems of transistors currently under development with potential space application. This system will allow researchers to examine next generation power transistors and devices to define their capabilities before transitioning to space. Using a cryogenic temperature range down to 80K, as well as temperatures as high as 400K, this new evaluation system is technically superior to existing microwave load pull systems which work mainly at room temperature. This evaluation identifies transistors that can potentially be used in space components or subsytems without elaborate environmental protections and controls. Early identification of the robustness of transistors allows for cost-effective development of lighter weight amplifiers and arrays for space use.